TECHNICAL MANUAL

MODEL 4017C1 -5

POWER MEASURING SET

Ser # 102 038

GENERAL MICROWAVE CORPORATION

155 MARINE STREET • FARMINGDALE, L.I., NEW YORK 11735

MP MASTER

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TECHNICAL MANUAL

MODEL 4017C1 -5

POWER MEASURING SET

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ERRATA AND CHANGES

Model 476 Power Meter

(For Serial No. XX2026 and higher)

1. Make the following addition to Table 5.1, Page 5-9

   R111/RES, FXD, COMP, 470 OHMS ±5%;

   P/N RC07GF471J/1 (in column "D")/01121

2. Change "R111-R200 NOT USED" to "R112-R200 NOT USED"
3. In step 4-19G on page 4-8, change "--- -1 and +2 VDC ---" to "--- -1.5 and +1.5 VDC ---".
4. In step 4-19R on page 4-8, change "Step 6 indication" to "Step (P) indication".

11/21/77

1.0 GENERAL

This Technical Manual consists of the following in addition to this document:

Operating and Service Data for GMC Model 476 Thermoelectric Power Meter

Operating Instructions for Model N4240A Coaxial tft Power Head

Tech Data for Model 4017C1 Power Measuring Set

GMC drawing 8557

2.0 INTRODUCTION

The Model 4017C1 consists of a Model 476 Power Meter, a Model N4240A tft Power Head, a set of four precision attenuators, and a carrying case.

3.0 OPERATION

Operation of the Model 4017C1 is identical to that described in the attached power meter literature. To increase the maximum power level measuring capability beyond 10 mW, connect one or more of the precision attenuators furnished with the Model 4017C1 to the input of the Model N4240A. (Be sure to add the total value of attenuation connected to the Model N4240A to the Model 476 indication.)

FUNCTIONAL DESCRIPTION

The 4017C1 is a portable power measuring set, consisting of a thermoelectric power meter, coaxial power head, precision attenuator set, and carrying case. The power meter, in conjunction with the coaxial power head,measures modulated, pulsed, and CW signals at average rf power levels from 0.03 uW to 10 mW, over the frequency range from 0.01 to 18 GHz. The attenuator set operates over the frequency range from DC to 18 GHz and extends the power measuring range of the 4017C1 test set.

Option 03 adds an 18.0 to 26.5 GHz waveguide power head and Option 04, a 26.5 to 40.0 GHz waveguide head. Both operate with the power meter to measure average power levels from 0.03 uW to 10 mW.

Option 05 adds both the Option 03 and Option 04 power heads to the test set.

The power meter has ten ranges, selected by means of a front-panel rotary switch. Its front panel analog meter offers two linear power scales, 0 to 10 and 0 to 3, and one 0 to -10 dB scale. All scales are direct reading. A front-panel zero setting push-button is used to set zero on any power range. All others are automatically zero set simultaneously. A rear-panel output connector is provided for measurement systems using external recorders or digital voltmeters. The voltage output, when connecte to a load impedance of 1000 ohms or more, is a DC analog of the measured RF power. A 10 kHz oscillator is contained which enables calibration of the power meter and the power head without disconnecting the power head from the rf system under measurement.

The power heads interface directly with the input connector on the power meter front panel. Each power head is calibrated against NBS-certified standards and a graph of the calibration factor versu frequency is permanently mounted on the power head housing. A front-panel control on the power meter compensates for the power head calibration factor. The power heads also feature 300% overload protection, and field replaceable thermoelectric elements.

A carrying case houses all component parts of this equipment in shock resistant form-fitting inserts.

Specifications and prices subject to change without notice.

Litho in U.S

TECHNICAL (ELECTRICAL AND MECHANICAL) CHARACTERISTICS

POWER METER

Frequency Range: 0.01-40 GHz, depending on power head with which it is used

Average Power Range: 0.03 uW to 10 mW (direct)

Accuracy: ±1% of full scale on all ranges from 0 degree to +55 degrees C

Noise and Drift: Less than 1.5 % peak on most sensitive range; proportionately less on less sensitive ranges

Self Calibration: Internal 10 kHz oscillator

Calibration Oscillator Accuracy: ±0.3% at +25°C

Zero Set: Automatic on all ranges, operated by front-panel button

Rf Disable: Provides ground closure at rear connector in auto-zero and calibration modes

Scale Selection: Automatic indicator corresponding to power head in use

Power Head Calibration Factor Compensator: Continously variable front-panel control with range from 86 to 100%

Response Time (Time Constant): Less than 0.5 second for seven upper ranges; less than 1.5 seconds for three most sensitive ranges

Recorder Output: Rear mounted connector provides output proportional to indicated power; minimum load resistance of 1000 ohms

Meter: 4.5 inches, mirror-backed scale, taut band suspension

Input Power: 115 V ±10%, single phase AC, at 50 Hz ±5%, 60 Hz ±5%, and 400 Hz ±5%

Input Connector: Front panel mounted

COAXIAL POWER HEAD

Rf Input: N male, 50 ohms

Frequency Range: 10 MHz to 18 GHz

Power Range: 0.03 uW to 10 mW (direct)

VSWR: 1.5 from 0.010 to 10 GHz

1.6 from 10 to 18 GHz

Peak Power: 1 W (direct), for pulse duration of 5 usec or less (maximum pulse energy of 5 W-usec); 500 W (with attenuator), at 0 to +25°C

Temperature Coefficient: 0.1%/°C

OPTION 03 WAVEGUIDE POWER HEAD

Rf Input:

Waveguide type: RG-53/U
Flange type: UG-595/U

Frequency Range: 18 to 26.5 GHz

Power Range: 0.03 uW to 10 mW

VSWR: 1.5 max.

Peak Power: 1 W for pulse duration of 5 usec or less (maximum pulse energy of 5 W-usec)

Temperature Coefficient: 0.1%/°C max.

OPTION 04 WAVEGUIDE POWER HEAD

Rf Input:

Waveguide type: RG-96/U
Flange type: UG-599/U

Frequency Range: 26.5 to 40 GHz

Power Range: 0.03 uW to 10 mW

VSWR: 1.65 max.

Peak Power: 1 W for pulse duration of 5 usec or less (maximum pulse energy of 5 W-usec)

Temperature Coefficient: 0.1%/°C

RELATION TO OTHER EQUIPMENT: None

EQUIPMENT REQUIRED BUT NOT SUPPLIED: None

MAJOR COMPONENTS

QTY	ITEM	DIMENSIONS (Inches)	WEIGHT (Lbs.)
	Power Measuring Set, 4017C1, includes:		
1	Thermoelectric Power Meter, 476	6.1H x 5.125W x 11.13D	7 lbs.
1	Power Head, N4240A	2.88L x 1.29 dia plus umbilical five foot interconnecting cable	3 oz.
1	Precision Attenuator Set (DC-18 GHz) 3 ± 0.3 dB 6 ± 0.3 dB 10 ± 0.5 dB 20 ± 0.7 dB	2.46L x 0.81 dia (each)	0.5 oz. (each)
1	Option 03 Power Head, K4240C	3.74 L x 2.12 dia plus umbilical five foot interconnecting cable	32 oz.
1	Option 04 Power Head, A4240C	3.74 L x 2.2 dia plus umbilical five foot interconnecting cable	32 oz.
	Option 05 consists of 1 each Option 03 and Option 04 power heads as described above		
1	Carrying Case	10.75 x 15.75 x 20.25	15 lbs.

OPERATING AND SERVICE DATA

FOR

MODEL 476 POWER METER

(For Serial No. XX2026
and higher)

GENERAL MICROWAVE CORPORATION
155 Marine Street
Farmingdale, New York 11735

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9/15/77

TABLE OF CONTENTS

	Page
SECTION I, GENERAL	1-0
SECTION II, OPERATION	2-1
2.1 OPERATING CONTROLS, INDICATORS AND CONNECTORS	2-1
2.2 INSTALLATION AND OPERATING PROCEDURES	2-1
SECTION III, THEORY OF OPERATION	3-1
3.1 GENERAL CIRCUIT DESCRIPTION	3-1
3.2 DETAILED CIRCUIT DESCRIPTION	3-1
Low Pass Filter, Modulator and Input Transformer	3-1
Low-Noise Preamplifier	3-5
Active Bandpass Filter	3-5
Phase Inverter and Demodulator	3-5
Integrating Amplifier	3-5
Feedback Network	3-5
Gain Programmable Amplifier	3-5
Auto-Zero Network	3-5
Variable Gain Amplifier	3-5
Power Head Linearizer	3-6
Power Head Decoder	3-6
Power Supplies	3-6
Modulator/Demodulator Driver	3-6
10 kHz Oscillator	3-6
SECTION IV, MAINTENANCE	4-1
4.1 GENERAL	4-1
4.2 INSTRUMENT REPAIR	4-1
Gaining Access	4-1
4.3 ISOTHERMAL ASSEMBLY REPAIR	4-1
Auto-Zero Module	4-3
4.4 REPLACEMENT OF FRONT PANEL COMPONENTS	4-3
4.5 EQUIPMENT REQUIRED FOR TEST AND CALIBRATION	4-3
4.6 SPECIAL MAINTENANCE PRECAUTIONS	4-4
Warmup	4-4
4.7 POWER SUPPLY TESTS	4-4
4.8 CHOPPER DRIVE ADJUSTMENT	4-5
4.9 RANGE LAMP CHECKS	4-5
4.10 FILTER ADJUSTMENT	4-5
4.11 DC ZERO ADJUSTMENTS	4-5
4.12 POWER HEAD CALIBRATION CIRCUIT ADJUSTMENTS	4-5
4.13 RANGE-TO-RANGE ADJUSTMENTS AND ACCURACY TEST	4-6
4.14 NOISE TEST	4-7
4.15 ZERO CARRYOVER TEST	4-7
4.16 RESPONSE TIME TEST	4-7
4.17 RF BLANKING TEST	4-7
4.18 CAL MODE AUTO RANGING TEST	4-7
4.19 AUTO-ZERO MODULE TEST	4-7
SECTION V, PARTS LIST	5-1
5.0 GENERAL PARTS INFORMATION	5-1

LIST OF ILLUSTRATIONS

Figure	Title	Page
1.1	GMC Model 476 Power Meter	1-2
3.1	Block Diagram, Model 476 Power Meter	3-2
3.2 (a)	Schematic Diagram, Model 476 Power Meter	3-3
3.2 (b)	Schematic Diagram, Model 476 Power Meter	3-4
4.1	Assembly of Isothermal Assembly Input Leads	4-2

LIST OF TABLES

Table	Title	Page
1.1	Model 476 Specifications	1-0
1.2	Salient tft Power Head Characteristics	1-1
4.1	Required Test Equipment	4-2
5.1	Parts List	5-1

SECTION I

GENERAL

The General Microwave Model 476 Thermoelectric Power Meter in conjunction with the 4200 Series of *tft*® Coaxial and Waveguide Power Heads*, forms a highly accurate instrument for measuring microwave power over a wide frequency and power range. The Model 476 indicates the average power absorbed by the associated 4200 Series *tft* power head. The *tft* element within the power head responds only to the rms value of the input signal and is completely insensitive to wave shape. Pulsed, amplitude-modulated and cw signals are measured with equal accuracy. The unit may be used in a variety of applications, including portable and field use when used with the optional Model 981-1 Rechargeable Battery Pack.

The Model 476 features self-calibration employing a highly stable internal 10 kHz oscillator. This circuit insures that power meter gain of the Model 476 is precisely matched to the sensitivity of the individual 4200 Series *tft* power head in use. Calibration is conveniently checked and adjusted at the Model 476 front panel without disconnecting the power head from the rf system under measurement.

The Model 476 also features automatic zero setting by a front-panel push-button that can be activated on any range. Other features include automatic scale selection to insure that only the scale corresponding to the dynamic range of the associated *tft* power head is activated, an output jack for measurement systems using external recorders or digital voltmeters, and an rf-disable ground closure at a rear connector for use in auto-zero and calibration modes.

Specifications of the Model 476 are contained in Table 1.1. Characteristics of the 4200 Series *tft* power heads are shown in Table 1.2.

TABLE 1.1

MODEL 476 SPECIFICATIONS

DYNAMIC RANGE

	MICROWATTS						MILLIWATTS					
FULL-SCALE RANGE	0.3	1.0	3.0	10	30	100	0.3	1.0	3.0	10	30	100
dBm	-35	-30	-25	-20	-15	-10	-5	0	+5	+10	+15	+20

Type 4240 Heads

Type 4241 Heads

ACCURACY	±1% of full scale on all ranges from 0°C to +55°C.
NOISE AND DRIFT	Less than 1.5% peak on most sensitive range; proportionately less on less sensitive ranges.
SELF CALIBRATION	Self contained 10 kHz oscillator.
10 kHz OSCILLATOR ACCURACY	±0.3% at +25°C.
ZERO SET	Automatic on all ranges, operated by front-panel button.
RF DISABLE	Provides ground closure at rear connector in auto-zero and calibration modes.
SCALE SELECTION	Automatic indicator corresponding to power head in use.
POWER HEAD CALIBRATION FACTOR COMPENSATOR	Continuously variable front-panel control; range is 86 to 100%.
RESPONSE TIME (TIME CONSTANT)	Less than 0.5 second for eight upper ranges; less than 1.7 seconds for two most sensitive ranges.

*Thin Film Thermoelectric Patent No. 3,384,819

TABLE 1.1 (CONT'D)

DVM/RECORDER OUTPUT	Rear mounted connector provides output proportional to indicated power; minimum load resistance of 1000 ohms.
INPUT POWER	115/230V ±10%, 50–1000 Hz, 5 watts
INPUT CONNECTOR	Front panel mounted.
METER	4½", mirror scale, taut-band suspension
NOMINAL DIMENSIONS	6.1" H x 5.1" W x 11.3" D (155 x 130 x 279 mm)
APPROXIMATE WEIGHT	7 lbs. (3.2 kg)
ACCESSORIES AVAILABLE	
Model 981-1 Rechargeable Battery Pack Model 983-4 Rack Adapter	
OPTION AVAILABLE	
Option 01.	Input connector re-positioned to the rear.

TABLE 1.2

SALIENT *tft* POWER HEAD CHARACTERISTICS

COAXIAL

Model	Input Connector Type	Frequency Range (GHz)	Power Range	Max Pulse Energy+ (W-usec)	Max Pulse Power+ (W)	Max Pulse Duration+ (usec)***	MAX VSWR
M4240A	SMA-Male	0.01-18**	30 nW to 10 mW (-45 to +10 dBm)	5	1	5	1.5 from 0.010 to 0.015 GHz
N4240A	N-Male	0.01-18					
P4240A	APC-7						
M4241A	SMA-Male	0.01-18**	300 nW to 100 mW (-35 to +20 dBm)	30	15	2	1.35 from 0.015 to 10GHz 1.6 from 10 GHz to upper frequency limit
N4241A	N-Male	0.01-18					
P4241A	APC-7						

WAVEGUIDE

Model	Frequency Range (GHz)	Waveguide Type	Flange Type	Power Range From	Power Range To	Max Pulse Energy+ (W-usec)	Max Pulse Power+ (W)	Max Pulse Duration+ (usec)***	Max VSWR
X4240C	8.2-12.4	RG-52/U	UG-39/U	30 nW (-45dBm)	10 mW (+10dBm)	10	2	5	1.5
U4240C	12.4-18.0	RG-91/U	UG-419/U			10	2	5	
K4240C	18.0-26.5	RG-53/U	UG-595/U			5	1	5	
A4240C	26.5-40.0	RG-96/U	UG-599/U			5	1	5	1.65

+At +25°C
**Available for operation to 22 GHz on special order
***At max pulse power

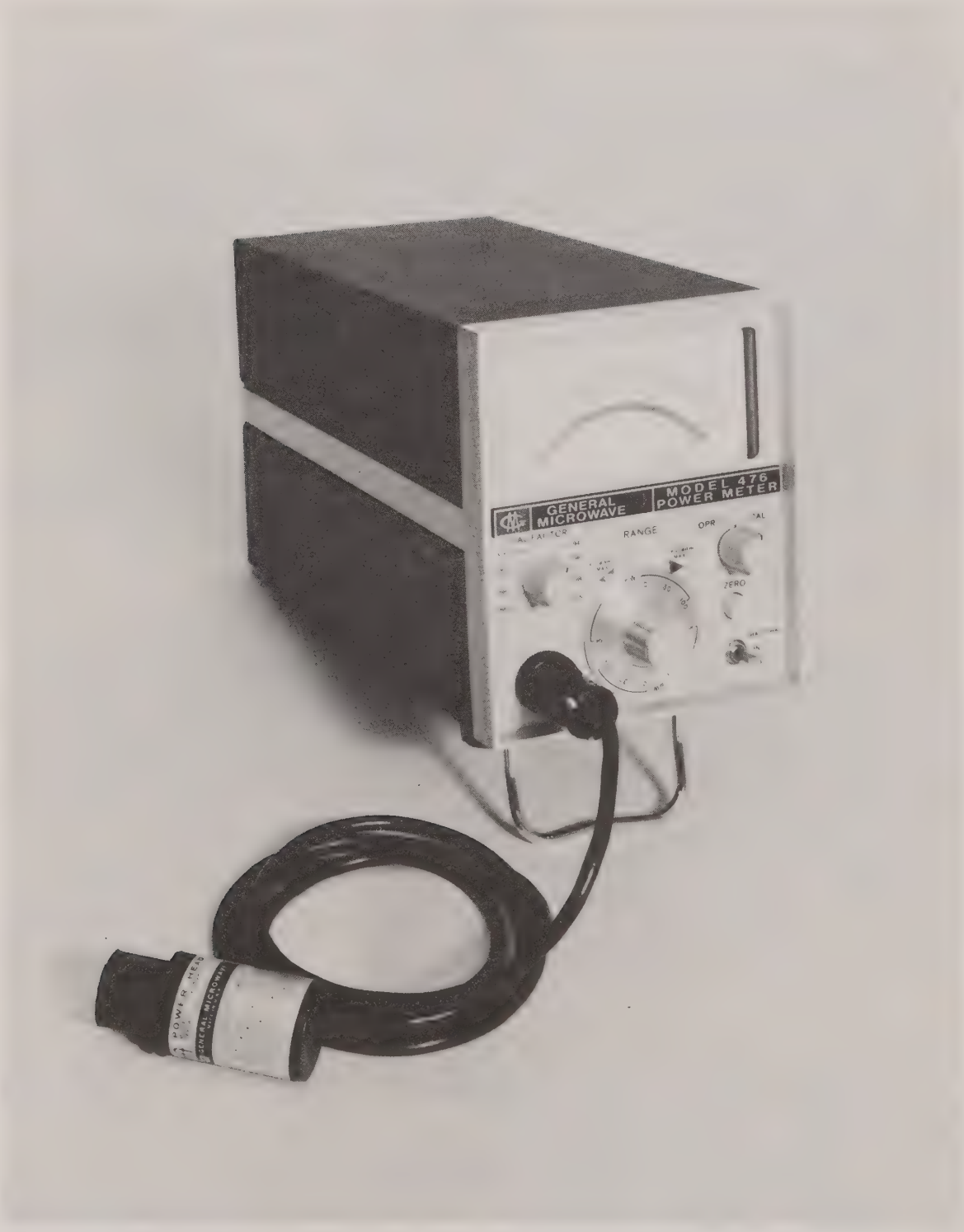


FIGURE 1.1 GMC MODEL 476 POWER METER

SER # 182938.

SECTION II

OPERATION

2.1 OPERATING CONTROLS, INDICATORS AND CONNECTORS

Operating controls, indicators and connectors are located on both the front and rear panels. In addition to automatic presentation of the power reading, those on the front panel are:

RANGE: A 10-position rotary switch which permits selection of the desired operating power range.

+10 dBm/+20 dBm: The scale corresponding to the sensitivity of the *tft* power head in use is indicated by means of these two lamps located directly above the RANGE switch. *The indicated power level should not be exceeded.* See power head literature for additional details.

OPR-CAL: In the CAL position, this switch permits calibration of the *tft* power head in use by means of the associated screwdriver adjustment.

ZERO: This button is used to electrically zero the Model 476. Once used, it need not be used again when changing ranges.

Power: This three-position switch energizes the Model 476 using either ac line power or optional battery power. It also permits the battery condition to be checked.

CAL FACTOR: This control permits automatic compensation for the calibration factor of the *tft* power head in use. The range is 86 to 100%.

Controls and connectors located at the rear of the Model 476 are:

115/230V: This switch permits application of either 115 volt or 230 volt ac power. If replacement of the associated fuse becomes necessary, insure that the replacement conforms with the description given in the Table of Replaceable Parts.

OUTPUT: These binding posts provide a calibrated analog voltage of the measured rf power with -0.3 and -1.0 volt corresponding to full scale on the "3" and "10" ranges, respectively. The minimum load resistance is 1000 ohms.

RF BLANKING: A ground return is provided at this connector in the auto-zero and calibration modes as an aid when the rf power source can be turned off by a relay.

2.2 INSTALLATION AND OPERATING PROCEDURES

With the exception of the following, there are no special precautions to be observed when installing or using a Model 476 and *tft* power heads other than the normal good practice associated with accurate measurement instruments and microwave components. It is suggested that a warm-up period of about 15 minutes be allowed to permit circuit stabilization. The flange or connector of the *tft* power head should be handled with care to avoid scratching or marring the surfaces and connecting parts, and should be covered with a protective cap when not in use to prevent accumulations that can affect performance. Power ratings of the *tft* power heads should not be exceeded since permanent damage to the *tft* element may result. Although the power ratings are conservatively applied, the margin of safety should not be deliberately narrowed.

If it is desired to use a recorder to obtain a plot of power output versus time, use the OUTPUT binding posts. Refer to paragraph 2.1 for additional details.

To operate a Model 476, proceed as follows:

(a) If ac line power is to be used, set the 115V-230V switch as required, connect to the ac power source, and set the Power switch to ON. Note that beat notes will arise between certain line frequencies and harmonics of the chopper frequency, producing erratic performance of the Model 476. This also occurs when a battery equipped model is connected to an ac line. Line frequency bands to be avoided are: 53-57, 104-116, 162-168, 217-223, 272-278, 327-333, 382-388, 437-443, 492-498, 547-553, 602-608, 657-663, 712-718, 767-773, 822-828, 877-882, 932-938 and 987-993 Hz.

(b) If the optional battery power is to be used, check battery condition by setting the Power switch to BAT CHK and verifying that the front-panel meter indicates in the BAT CHGD region. The Model 476 can be operated about 12 hours on a fully-charged battery. The charging cycle is about 16 hours for a complete charge. (Refer to the Model 981-1 literature for complete battery data.)

Battery charging is accomplished by connecting the Model 476 to an ac line power source and setting the Power switch to ON. When measuring rf power using a battery-equipped Model 476 while connected to ac line power, the previous comment regarding beat notes will be applicable.

(c) Connect the *tft* power head to the connector on the front panel of the Model 476. Do not connect the *tft* power head to the source of rf power at this point. (If the power to be measured is not approximately known, use a 100 mW *tft* power head if available, and, after application of rf power as described below, reduce the power range and/or change *tft* power heads as required.)

CAUTION

To avoid damage to the *tft* power head, use an appropriate attenuator or coupler to reduce the power level to be measured to a safe value if the power level could possible exceed the power rating of the *tft* power head in use.

(d) Determine the calibration factor from the graph mounted on the *tft* power head and set the CAL FACTOR control on the Model 476 to the value indicated.

(e) Allow a 15-minute warm-up period, check that the OPR-CAL switch is set to OPR, and in the absence of rf power, zero the Model 476 on any range using its ZERO button.

(f) On any range and in the absence of rf power, set the OPR-CAL switch to CAL and adjust the CAL screwdriver control for the appropriate indication on the front-panel meter scale (at 10 if a coaxial *tft* power head is in use, and near 8 if a waveguide *tft* power head is in use). Set the OPR-CAL switch to OPR.

(g) Connect the *tft* power head to the source of rf power to be measured, adjust the RANGE switch for an on-scale reading, and read the power directly on the meter. The power range at which the unit is set (adjacent to the illuminated scale indicator lamp) determines the meter scale to be used.

NOTE

If the RANGE switch is set to one of the more sensitive ranges shortly after calibration, it will be noted that the meter will slowly return to zero. This is due to thermal cooling of the *tft* element. Allow the meter to return to zero before making measurements. Do not re-zero the unit during this interval.

SECTION III

THEORY OF OPERATION

3.1 GENERAL CIRCUIT DESCRIPTION

The Model 476 is basically a chopper-stabilized dc amplifier featuring very low noise, high gain and high gain stability. A self-contained analog meter indicates measured power.

Figures 3.1 and 3.2 are block and schematic diagrams, respectively, of the overall unit. The dc input signal from the *tft* power head is applied to the Modulator through the Low-Pass Filter network. The square-wave output signal of the Modulator is stepped-up by the Input Transformer and applied to the Low-Noise Preamplifier. The signal is amplified in this circuit and coupled to the Active Bandpass Filter, where much of the noise and other spurious signals are removed. The resulting sine wave signal is then coupled directly, and also through the 180-degree Phase Inverter, to the Demodulator. The full-wave Demodulator, which is synchronously driven with the Modulator, recovers the input dc signal at a greatly amplified level.

The output of the Demodulator is amplified in the Integrating Amplifier and coupled back to the input network through the Range Switching feedback network. This feedback path provides a high degree of degeneration, thus, gain stability, and at the same time offers accurate control of amplifier gain.

The dc output of the Integrating Amplifier is also applied to the Gain Programmable Amplifier, which provides unity gain when the unit is set to its eight least sensitive ranges and a gain of 10 when the unit is in either of its two most sensitive ranges.

Output of the Gain Programmable Amplifier is applied to the Variable Gain Amplifier where compensation is made for the sensitivity of the *tft* power head in use, and for its calibration factor at the frequency of the signal under measurement. Output of the Variable Gain Amplifier drives the front-panel meter and the recorder OUTPUT binding posts.

The Gain Programmable Amplifier output is also used in conjunction with the Auto-Zero Network to automatically zero the Model 476.

Automatic compensation for non-linearity of the ( )4241A *tft* power heads when measuring power levels in excess of 10 mW is provided by the Power Head Linearizer network.

An automatic scale selection network (Power Head Decoder) is provided in the Model 476. Operation of this network is controlled by the interlock connections associated with pins 5 and 6 of the *tft* power head connector (pin 5 is shorted to pin 6 in 100 mW *tft* power heads; pins 5 and 6 are open in 10 mW heads). This network also automatically sets the unit to the proper range for calibration of the *tft* power head, regardless of the front-panel RANGE switch setting.

The Power Supplies provide the ±7.12 and +12 volt outputs required for operation of the Model 476. In addition, they contain provisions for recharging the optional battery that can be installed in a Model 476.

The Modulator/Demodulator Drive circuit is a complementary free-running multivibrator which provides a 110 Hz signal to drive the Modulator and Demodulator.

The Model 476 self-calibration feature utilizes a precision 10 kHz Oscillator network. The output of this network is applied directly to the *tft* power head in use by means of its umbilical cable. There is no need to disconnect the *tft* power head from the rf power source under measurement; however, rf power from the source should be turned off during calibration.

3.2 DETAILED CIRCUIT DESCRIPTION

LOW PASS FILTER, MODULATOR AND INPUT TRANSFORMER. This circuit consists of G1A and Input Transformer T1. The input signal to the Model 476 is applied to the moving arm of Modulator G1A, which is one half of a mechanical chopper, through a Low Pass Filter that is an integral part of the chopper transformer. The filter isolates the Model 476 amplifier from the 10 kHz signal that is applied to the *tft* power head during the calibration mode.

To minimize thermal emf's in the input circuit, unplated copper leads are employed throughout, and all connections are crimped connections. The Modulator and Transformer also employ copper leads, and the transformer is carefully shielded to minimize hum pickup. The Model 476 input connector employs special pins for the signal lines.

The dc amplifier feedback signal and the dc offset voltage from the Auto-Zero Circuit are applied to the center-tap of the primary of Input Transformer T1. The input and feedback/dc offset signal is

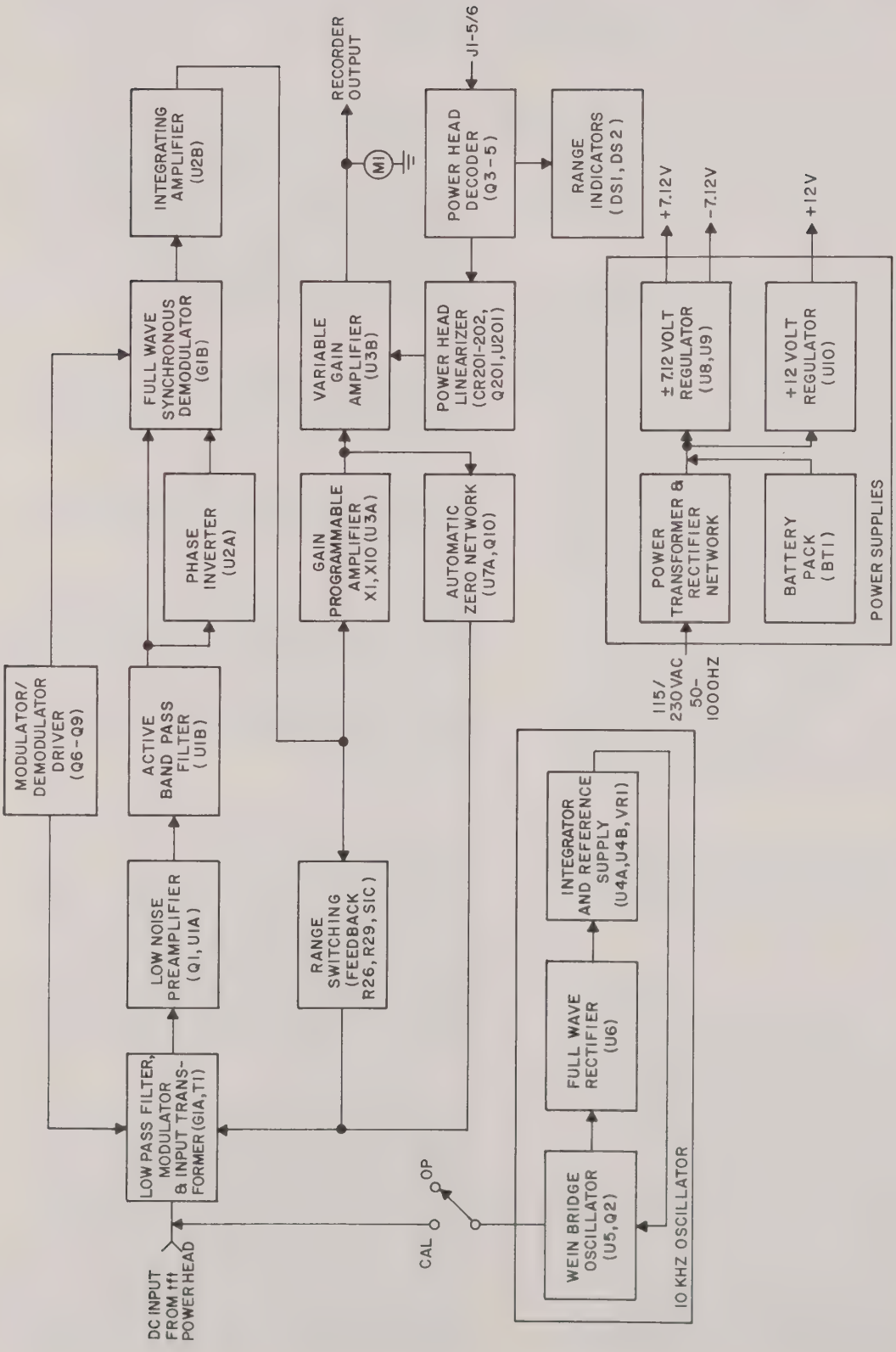


FIGURE 3.1 BLOCK DIAGRAM, MODEL 476 POWER METER

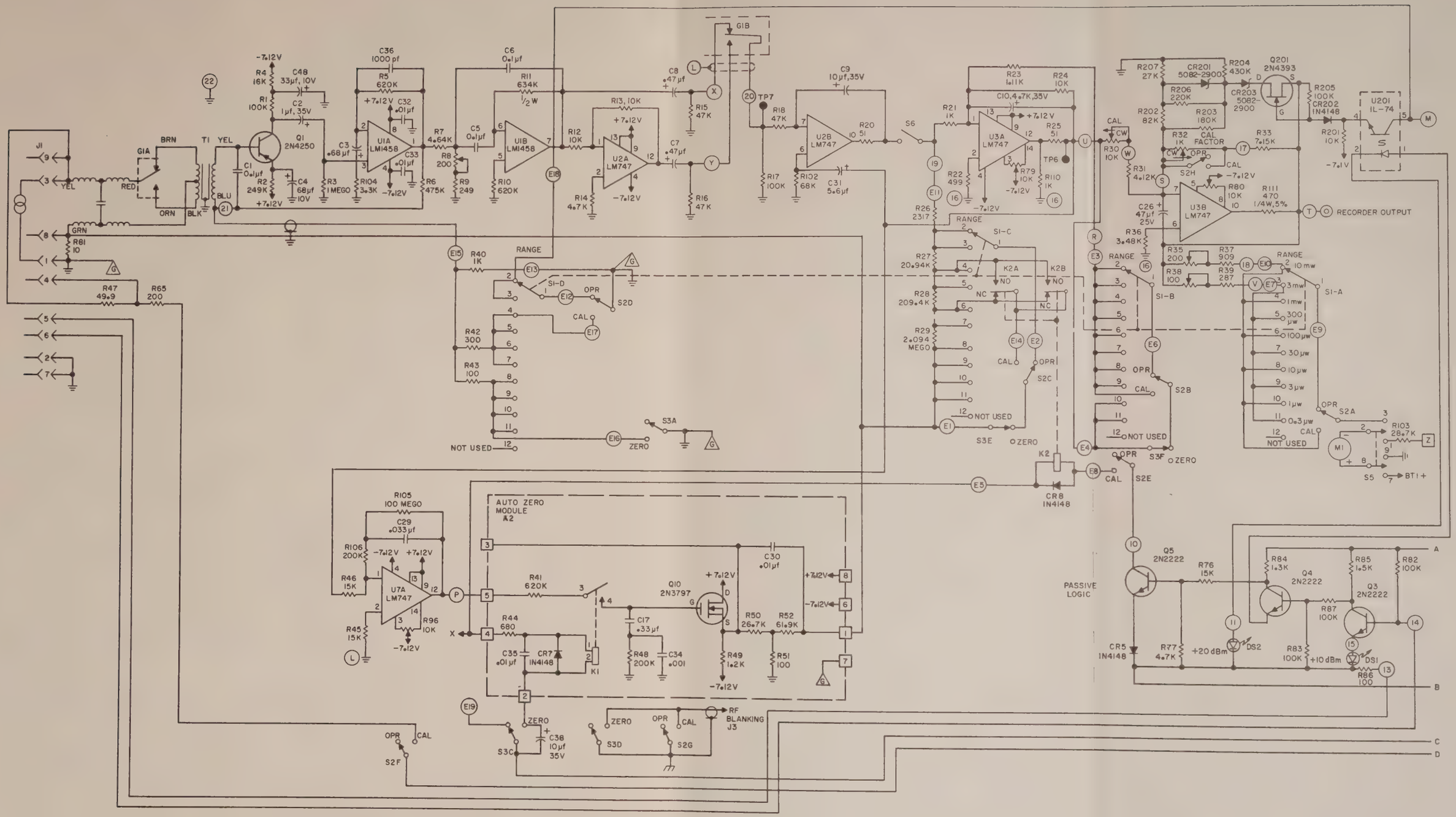


FIGURE 3.2 (a) SCHEMATIC DIAGRAM, MODEL 476 POWER METER

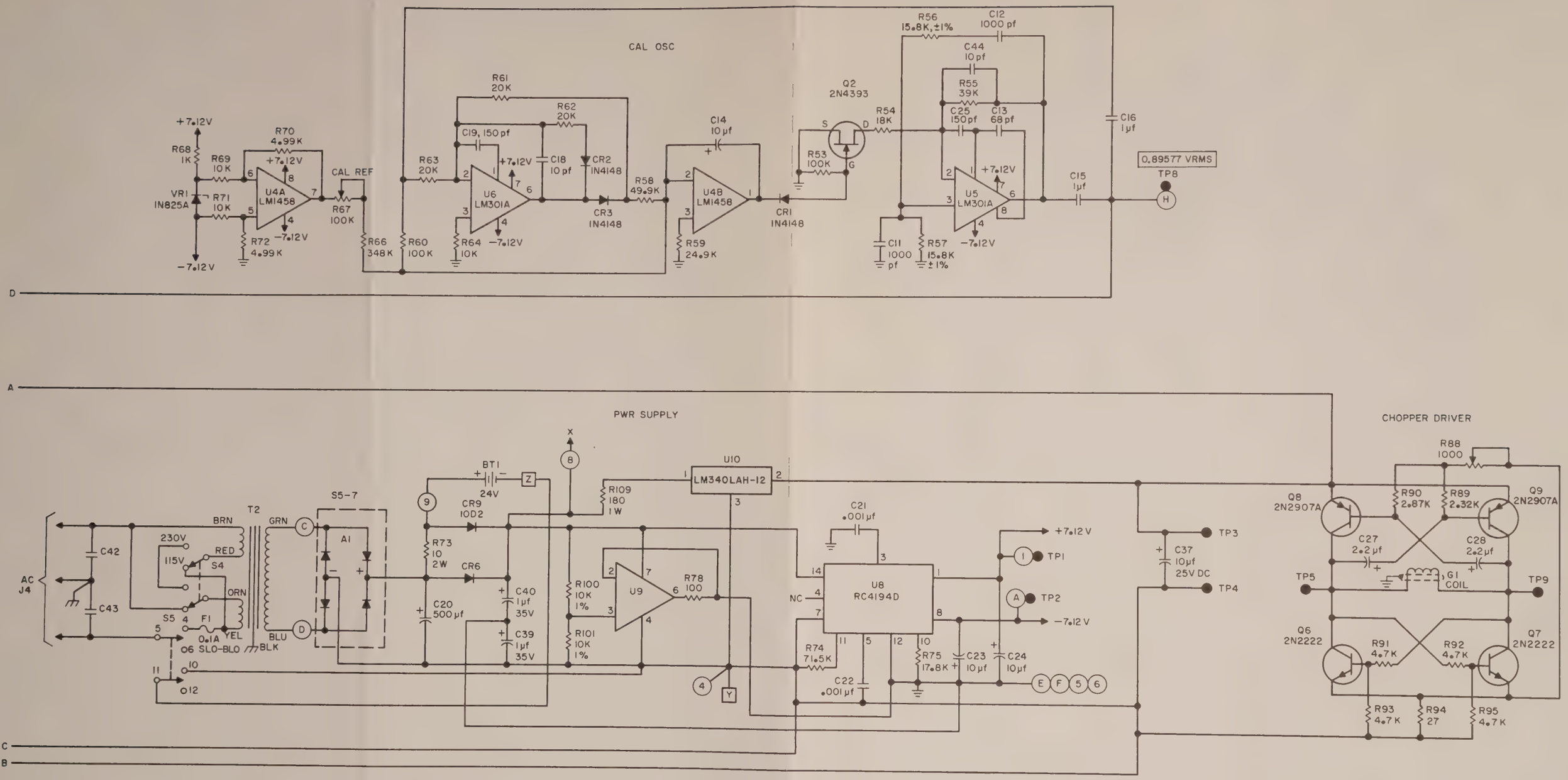


FIGURE 3.2 (b) SCHEMATIC DIAGRAM, MODEL 476 POWER METER

alternately applied to each half of the transformer primary, producing a square-wave signal proportional to the difference of the two inputs. This signal is stepped up in the transformer and applied to the Low Noise Preamplifier.

LOW-NOISE PREAMPLIFIER. This circuit consists of transistor Q1 and amplifier U1A. The square-wave signal from the input network is amplified in this circuit and applied to the Active Bandpass Filter.

ACTIVE BANDPASS FILTER. This circuit consists of the U1B stage. The square-wave signal from the Low-Noise Preamplifier is amplified by U1B, which is an active bandpass amplifier/filter network centered at 110 Hz that removes most of the noise and other spurious signals present. Fine frequency turning for the stage is provided by means of R8. The output of the stage is applied to the Phase Inverter and the Demodulator.

PHASE INVERTER AND DEMODULATOR. The Phase Inverter consists of U2A; the Demodulator is the second half of a mechanical chopper. The outputs of U2A and U1B, which are 180 degrees out of phase with each other, are applied to Demodulator G1B. The full-wave Demodulator is synchronously driven with the input Modulator at a 110 Hz rate, thereby eliminating much of the remaining nonsynchronous noise and spurious signals.

INTEGRATING AMPLIFIER. This circuit consists of the U2B stage. Output of the Demodulator is amplified in U2B and applied to the Gain Programmable Amplifier. In addition, it is applied as a feedback signal to the input network through the Feedback Network.

FEEDBACK NETWORK. This network consists of resistors R26 through R29, and is controlled by S1C. The Integrating Amplifier dc output provides the feedback signal around the entire dc amplifier. The magnitude of the feedback signal, therefore the dc amplifier gain, is determined by the ratio of the sum of R26, R27, R28 and R29 which, in turn, depends upon the range setting, and the value of R81.

The presence of spurious dc signals at the input to the dc amplifier must be anticipated because of thermal emf's, as well as any slight unbalance that may be present in *tft* power head. Accordingly, to correct for these offset signals, a small compensating dc voltage that is derived from the Auto-Zero Circuit is introduced with the feedback signal.

GAIN PROGRAMMABLE AMPLIFIER. The amplifier circuit described so far is capable of providing a 45 dB dynamic range. To provide the additional 10 dB of dynamic range needed when the Model 476 is required to operate in its two lowest ranges, the Gain Programmable Amplifier network is employed. This network consists of U3A and associated components. When the unit is set to any of its eight less sensitive ranges, the Gain of the U3A network is 1 (the ratio of R23 in parallel with R24 (1000 ohms) to R21 (1000 ohms)). When the unit is set to either of its two most sensitive ranges, the Gain of U3A is increased to 10 (the ratio of R24 (10,000 ohms) to R21 (1000 ohms) since R23 is removed from the circuit by S1B.

Potentiometer R79 provides a dc-offset adjustment for the U3A stage.

AUTO-ZERO NETWORK. This circuit consists of U7A and Q10. When auto-zeroing is initiated, relay K1 is energized, and the output of high-gain comparator U7A starts to charge capacitor C17 if the input to U7A at pin 1 is not zero. The voltage on C17 is then coupled through FET Q10 to the Input Transformer T1. This voltage will force the output of the overall amplifier loop (at pin 12 of U3A) to zero. Circuit parameters are such that once C17 has been charged to the proper value for a zero output from U3A with no rf input to the unit, C17 will maintain its charge and relay K1 can be de-energized.

Note also that when the unit is being zeroed, a ground signal becomes available at the RF BLANKING connector via switch wafer S3D. This signal is provided to be used to disable the rf power source during zeroing.

VARIABLE GAIN AMPLIFIER. This circuit consists of the U3B stage. The gain of this stage is varied both to match the sensitivity of the amplifier to the *tft* power head to which the Model 476 is connected (via the front panel screwdriver adjustment R30) and to permit automatic compensation for the calibration factor of the *tft* power head in use (via the front panel CAL FACTOR control R32). Since both the absolute sensitivity and calibration factor of *tft* power heads differ, the gain of U3B in the Model 476 is varied as part of the operating procedure for the power meter with each *tft* power head employed. This permits the Model 476 to be used, without further adjustment, with any Series 4200 *tft* power head. Potentiometer R80 provides a dc-offset adjustment for the U3B stage.

Potentiometers R35 and R38 are meter sensitivity adjustments for the 10 mW and 3 mW meter scales, respectively. With the instrument set to the 10 mW range the U3B output is at one volt. R35 is then adjusted for a reading of 10 on the 0-10 scale. With the instrument set on the 3 mW range, the U3B output is at 3.16 volts and R38 is adjusted so the meter reads 10 on the 0-10 scale.

POWER HEAD LINEARIZER. This network consists of CR201, CR202, Q201 and U201. When the unit is in either of its two least sensitive ranges and a 100 mW *tft* power head is connected, the power head linearizer network is energized (pin 5 of the Opto-Isolator light-sensitive transistor is grounded through S1D and S2D. Current flows through the Opto-Isolator light-emitting diode from the Power Head Decoder network. Transistor Q201 is then activated, thereby energizing the CR201/CR203 shaping circuit. The circuit parameters are such that proper gain compensation is incorporated to correct for the non-linearity of the 100 mW power heads when measuring power levels in excess of 10 mW.

POWER HEAD DECODER. This circuit consists of Q3, Q4 and Q5. When pins 5 and 6 in the *tft* power head connector are shorted together (100 mW power heads), transistor Q4 is turned on. Current will flow through its emitter, through the light-emitting diode in the Opto-Isolator, and return through the +20 dBm front-panel indicator lamp DS2. When pins 5 and 6 are not shorted, Q3 will conduct, thereby illuminating the +10 dBm indicator lamp.

When the unit is set to its calibrate mode, it is programmed to its 1 mW range, regardless of which type of power head is connected or where the front panel RANGE switch is set. This is accomplished automatically by means of relay K2 in conjunction with S1C. When S2 is set to CAL, transistor Q5 will energize K2 if a 10 mW power head is connected, thereby setting the unit to the 1 mW range. If a 10 mW power head is in use, K2 will be de-energized and the unit will remain in the 1 mW range.

POWER SUPPLIES. This circuit consists of power transformer T2, rectifier network A1, and U8, U9 and U10. Output voltage from the full wave rectifier A1 is applied to amplifier U9 which derives a ground reference for the instrument. This establishes equal positive and negative voltages which are applied to pins 7 and 14 of voltage regulator U8, where they are converted to ±7.12 volt supplies that are used in all low-level circuits in the Model 476. The output of the full-wave rectifier is also applied to regulator U10, and the resultant +12 volt output at pin 2 is used in the Modulator/Demodulator driver and power head decoder networks. Note that this level is measured with respect to pin 3 of U10 and not ground.

MODULATOR/DEMODULATOR DRIVER. This circuit, consisting of Q6-Q9 and associated components, is an astable multivibrator which is adjusted by potentiometer R88 for operation at 110 Hz. The output is applied directly to the chopper drive coil. The values of R89 and R90 are chosen to obtain a symmetrical square-wave output from the circuit.

10 kHz OSCILLATOR. The 10 kHz Oscillator network consists of Wein Bridge Oscillator U5/Q2, precision Full-Wave Rectifier U6, and Integrator and Reference Supply U4A/U4B/VR1. The output of the Wein Bridge Oscillator is rectified in Full-Wave Rectifier U6. The positive half of the sine wave is rectified by CR2, and applied to U4B at pin 2. A second input to U4B pin 2 is the output of the Wein Bridge Oscillator via R60. (Note that since the value of the signal through R60 is approximately twice the value of R58, the peak value of the signal through R60 will be about half the peak value of the signal through R58.) A third input to U4B pin 2 is a highly stable reference voltage derived from temperature-compensated diode VR1 through U4A. Fine adjustment of the reference level is provided by potentiometer R67.

The output of U4B is the combination of the signals at pin 2 of U4B, and is integrated to a dc level that is used to control FET stage Q2, which in turn, controls the output level of the Wein Bridge Oscillator.

This completes the Wein Bridge Oscillator control loop. If anything occurs to change the 10 kHz output level that is applied to the *tft* power head, the feedback loop described above will act to force the level back to its original value.

SECTION IV

MAINTENANCE

4.1 GENERAL

The power meter should be maintained with the care associated with any precision electronic instrument. Because the voltages associated with the power head are of very low magnitude, input circuitry of the power meter is designed to eliminate the possibility of stray pickup. This section describes methods which must be used when replacing circuit components. Solder must never be used on input circuitry, since voltage drift due to dissimilar metals may occur.

Apparent malfunction may result from incorrect control settings or faulty input from external equipment to the unit itself. If the unit appears to operate improperly, first perform the following checks before proceeding with extensive troubleshooting:

. . . Insure that the ac supply voltage to the unit is the same as set on the rear panel switch (115 VAC - 230 VAC) and power switch is ON. Check line cord for proper connection.

. . . Check control settings. Insure that the OPERATE/CALIBRATE control is in OPERATE.

. . . Note that power input does not exceed the full scale power set on the RANGE switch.

. . . Check associated equipment. Insure that the microwave power circuit is operative and power is present at the power head.

After completing the foregoing, perform the following malfunction check.

. . . With the power head connected to the power meter, but without connection of the power head to a power source, perform the following check:

. . . Set the RANGE switch to maximum clockwise.

. . . Set OPERATE/CALIBRATE switch to OPERATE.

. . . Depress the ZERO button and verify that the meter responds by going to zero.

. . . Switch to CALIBRATE. The meter should respond with an upscale indication that may be adjusted with the CAL control to the appropriate calibration setting on the meter.

The preceding checks give a reasonable indication that the power meter system is operative, although a malfunction may still exist. The first step is to isolate a malfunction to either power head or power meter. If another power head is available, it may be substituted and the system rechecked. Also, if the power meter zeroes and correctly calibrates, but does not respond when it is known that power is present at the power head, a probable cause is a defective power head.

4.2 INSTRUMENT REPAIR

GAINING ACCESS. To gain access to the interior of a Model 476, proceed as follows:

(A) Remove the four screws at the rear of the unit which secure the top and bottom covers.

(B) Carefully remove the two covers by sliding them to the rear and then away from the unit.

(C) On the top of the unit, the component side of a large printed circuit board which contains all of the internal adjustments referenced in this section will be exposed. To gain access to the underside of the board for servicing or to remove the board, loosen the two plastic retainers located approximately one inch from the rear of the board which secure the board to the unit by pulling up on them. The board will now be free to swivel up to expose the underside. On some units, to swivel the board, it may be necessary to loosen the two screws on the sides of the unit that secure the printed circuit board connector. To remove the board from the unit, first turn the unit upside down and remove the cap from the chopper. Then turn the unit over and withdraw the board from its connector.

(D) With the exception of components located in the Isothermal Assembly and on the rear of the front panel, repair of the unit should now be obvious. To gain access to these components, refer to paragraph 4.3.

4.3 ISOTHERMAL ASSEMBLY REPAIR.

To replace the Isothermal Assembly components (R47, R65, R81, the chopper, chopper transformer and auto-zero module), proceed as follows to the extent necessary:

(A) Gain access to the interior of the unit as described in paragraph 4.2, and remove the large printed circuit board.

(B) Remove the four screws on the sides of the unit that secure the Isothermal Assembly.

(C) Carefully withdraw the Isothermal Assembly from the top of the unit noting the position of the harness.

(D) Remove the two screws and lockwashers that secure the housing to the assembly, and remove the housing. This will expose R81.

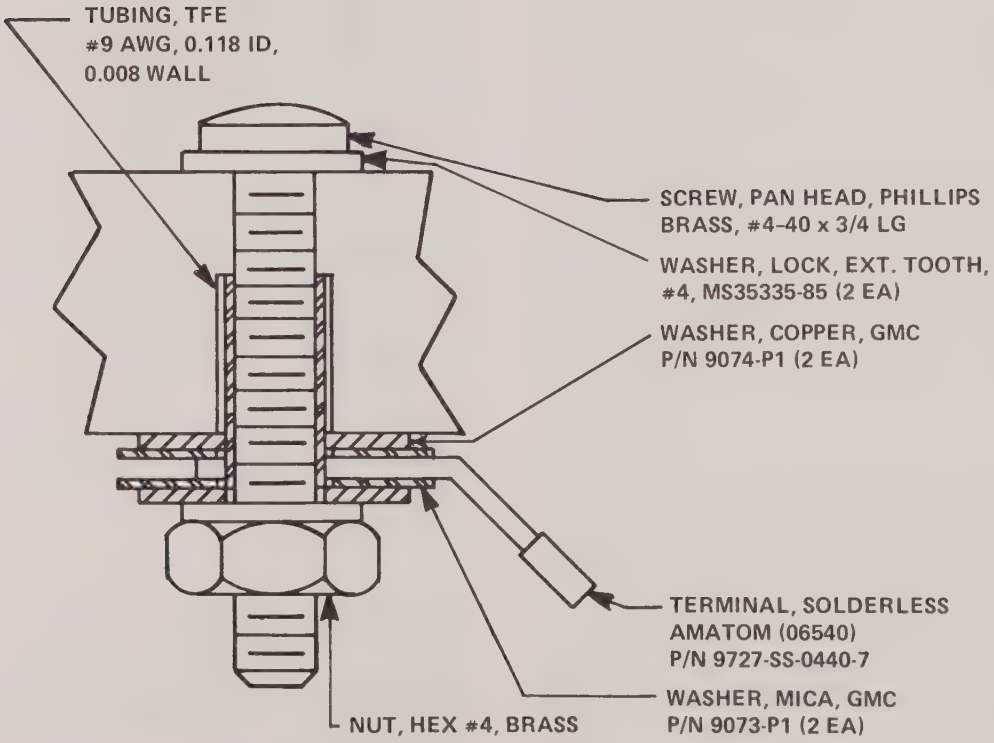


FIGURE 4.1 ASSEMBLY OF ISOTHERMAL INPUT LEADS

CAUTION

During this procedure, it is important that the large isothermal plate be kept totally free from contamination. Wear clean gloves at all times when handling it.

(E) Remove the four screws and lockwashers from the plane of the assembly on which the chopper, chopper transformer and auto-zero module are located, and carefully pull away the isothermal plate. The chopper, chopper transformer, auto-zero module, R47 (49.9 ohms) and R65 (200 ohms) are now available for replacement. If replacement of the chopper is required, apply purple "Loctite" to the threads of the screws and torque them to 4.5 inch-pounds after replacement. If it is necessary to remove any of the leads from the six screws extending through the isothermal plate, be certain to replace the parts and leads in exactly the same sequence they wer found (see figure 4.1) and tighten with a torque of 6 inch-pounds.

(F) Reassembly is the reverse of disassembly. When replacing the assembly, be sure the harness is restored to its original position.

AUTO-ZERO MODULE: This can be removed by unscrewing the module from the isothermal assy and unsoldering the wires.

4.4 REPLACEMENT OF FRONT-PANEL COMPONENTS

To replace any of the front-panel components, proceed as follows to the extent necessary:

(A) Gain access to the interior of the unit as described in paragraph 4.2.

(B) If replacement of any of the pins on the input connector is required, remove the defective pin(s) from the rear of the connector using an appropriate pin insertion/withdrawal tool (Amp P/N 91067-2/M24308/18-2 or equal), carefully noting their positions. Then remove the defective pin(s) from the harness and replace using an appropriate AFM8 Crimping Tool (Daniels Mfg. Corp., Bloomfield Hills, Mich. P/N M22520/2-01 with positioner M22520/2-08, or equal). Use only Amp. Inc. P/N 5064-58-2 pins should replacement be necessary. Then re-insert them in the connector using the other end of the tool used for removal.

(C) Snap off the front-panel bezel from the top, and remove by sliding it down.

(D) Rotate the CAL FACTOR, RANGE and OPR-CAL controls clockwise. and remove their knob caps using a thin screwdriver or knife. The screws which secure the knobs will now be visible.

(E) While holding the three controls firmly in their clockwise positions, loosen the three screws and remove the knobs.

(F) Remove the front panel marking plate.

(G) Remove the four screws on the front panel which secure the assembly to the unit, and carefully pull it away. It is now possible to replace the input connector (J1), Power Switch (S4), +10 dBm indicator lamp (DS1) and +20 dBM indicator lamp (DS2) without further disassembly of the unit.

If indicator lamp replacement is required, they can be easily removed from the front by first grasping and withdrawing the teflon bushing. Be sure to tag the leads so they are replaced properly.

If connector replacement is required, first remove the pins from the rear (carefully noting their positions) using the pin insertion/withdrawal tool referenced in step B above. Do not remove the pins from the harness. Then replace the connector and restore the pins using the other end of the tool used for removal.

(H) Remove the four screws on both sides of the unit that secure the meter assembly to the unit, and carefully pull the meter assembly away from the unit. It is now possible to remove and replace any of the remaining parts on the meter assembly, including the meter itself.

(I) Reassembly is the reverse of disassembly. When replacing, be sure the harness is restored to its approximate original position. When replacing the front panel knobs, set them to their clockwise positions (CAL FACTOR to 100, OPR-CAL to CAL, and align the .3 uW position on the dial with the +20 dBm indicator lamp) before tightening the screws.

4.5 EQUIPMENT REQUIRED FOR TEST AND CALIBRATION

Use the test equipment listed in table 4.1 or equivalents in the performance of the test and calibration procedures.

Table 4-1
REQUIRED TEST EQUIPMENT

Description	Mfr.	Model
Oscilloscope	Tektronix	564B/3A9
Electronic Counter	H-P	5302A
Digital Multimeter	Fluke	8600A
Variable Autotransformer	Superior Electric	116
Dc Voltage Source	Keithley	260
Ac Power Source	Elgar	201
Cable Assy — See para 4.6(E)	—	

4.6 SPECIAL MAINTENANCE PRECAUTION PRECAUTIONS

Do not make resistance checks on input transformer T1.

All circuits use either transistors or integrated circuits. Do not make resistance checks using the lower ohmmeter ranges.

Because of the very low dc voltages involved, repair of the Model 476 must be conducted with special care. Only crimped connections are to be made in the input circuit; if repair becomes necessary, do not solder any of the crimped connections. (Refer to paragraph 4.4B for the special tools required.) Use only gold plated copper lugs if replacement of any lugs becomes necessary.

WARM-UP

(A) Before applying ac power after repair, set the Power switch on the unit under test to OFF, and make continuity tests to insure that neither side of the line cord is connected to the chassis.

(B) Set the 115/230V switch to 115V and the OPR-CAL switch to OPR.

(C) Connect the Variable Autotransformer to a source of 115 volt, 60 Hz power. Connect the unit under test to the Variable Autotransformer and set the line voltage to 115 volts using the Multimeter. (Use the Multimeter when making all line voltage adjustments throughout this section.)

(D) Mechanically zero the front panel meter if required.

(E) Connect the Dc Voltage Source between pins 3 (-) and 1 (+) on the unit under test front-panel connector. To make the connections, it will be necessary to fabricate a cable assembly using a GMC 8376P1 connector to make the connection to the unit under test and a length of two-conductor shielded cable to make the connections to the Dc Voltage Source OUTPUT binding posts and ground. Use only 24/26 AWG unplated copper wire for the connections to pins 3 and 1, and all connections associated with these pins are to be crimped.

(F) Set the unit under test Power switch to ON. Allow a 15-minute warm-up period before proceeding.

4.7 POWER SUPPLY TESTS

Perform the following tests in any convenient sequence.

(A) Adjust the line voltage to 103 volts.

(B) Set the Multimeter for operation as a dc voltmeter on its 20 volt range and connect it between ground and TP1. (A convenient "ground" is the black OUTPUT binding post.) Verify that the indication on the Multimeter is between +6.76 and +7.83 volts. Note indication.

(C) Connect the Multimeter between ground and TP2 and verify that the Multimeter indicates between -6.76 and -7.83 volts. Note indication.

(D) Connect the Multimeter between TP3 and TP4 and verify that the Multimeter indication is between +11.4 and +12.6 volts. Note indication.

(E) Adjust the line voltage to 127 volts and repeat steps B through D. Verify that the three indications do not differ from those recorded above by more than 25, 25 and 150 mV, respectively.

(F) Remove the Multimeter and connect the Oscilloscope between ground and TP1. Verify that the peak-to-peak ripple is less than 4 mV.

(G) Connect the Oscilloscope between ground and TP2, and verify that the peak-to-peak ripple is less than 4 mV.

(H) Connect the Oscilloscope between TP3 and TP4, and verify that the peak-to-peak noise is nominally 600 mV (including spikes). Remove the Oscilloscope.

(I) Disconnect the unit under test from the Variable Autotransformer, adjust the line voltage to 230 volts, set the 115/230V switch to 230V, and connect the unit under test to the Variable Autotransformer. Readjust to 230 volts.

(J) Repeat steps B through F and verify that each of the three indications do not differ from those recorded above by more than 25, 25 and 150 mV, respectively. Remove the Multimeter.

(K) Disconnect the unit under test from the Variable Autotransformer, adjust the line voltage to 115 volts, set the 115/230V switch to 115V, and connect the unit under test to the Variable Autotransformer. Readjust to 115 volts.

4.8 CHOPPER DRIVE ADJUSTMENT

(A) Connect the Electronic Counter using a high-impedance 10X probe between TP5 and ground.

(B) Adjust potentiometer R88 for an indication on the Electronic Counter of 110 ±1 Hz. Remove the Electronic Counter.

4.9 RANGE LAMP CHECKS

(A) On the unit under test front-panel connector, connect pin 5 to pin 6, and verify that the +20 dBm indicator lamp goes on.

(B) Remove the connection between pins 5 and 6 and verify that the +10 dBm indicator lamp goes on.

4.10 FILTER ADJUSTMENT

(A) Set the unit under test to the 10 mW range.

(B) Set S6 within the unit under test to the left (when viewing it from the front of the unit).

(C) Set the Oscilloscope sensitivity to 200 mV/cm and connect it between TP7 and ground.

(D) Apply 13.6 uV to the unit under test using the Dc Voltage Source.

(E) Adjust potentiometer R8 for a symmetrical positive-going full-wave rectified sine wave on the Oscilloscope.

(F) Set the unit under test to the 1 uW range.

(G) Apply 431 nV to the unit under test using the Dc Voltage Source.

(H) Set S6 within the unit under test to the right, zero the unit under test, and set S6 to the left.

NOTE

Unless otherwise indicated, all references to "Zero the unit under test" throughout this section are performed as follows:

1. With the Dc Voltage Source adjusted for 431 mV output, set its RANGE switch to OFF.
2. Depress and hold the ZERO button on the unit under test for a zero indication on the unit under test front-panel meter.
3. Set the RANGE switch on the Dc Voltage Source to - (minus).

(I) Repeat step E and remove the Oscilloscope.

4.11 DC ZERO ADJUSTMENTS

(A) Set the unit under test to the 10 mW range, set the Dc Voltage Source RANGE switch to OFF, and set S6 within the unit under test to the right. Set the Multimeter for operation as a dc voltmeter on its 200 mV range and connect it between TP6 and ground.

(B) Adjust potentiometer R79 for a zero indication on the Multimeter.

(C) Connect the Multimeter between the OUTPUT binding posts.

(D) Adjust potentiometer R80 for a zero indication on the Multimeter.

(E) Zero the unit under test. While continuing to depress the ZERO button, adjust potentiometer R96 for a zero indication on the Multimeter. Release the ZERO button, and remove the Multimeter.

4.12 POWER HEAD CALIBRATION CIRCUIT ADJUSTMENT

(A) Set the OPR-CAL switch to CAL.

(B) Connect the Multimeter between TP8 and ground, and set it for operation as an ac voltmeter on its 2 volt range.

(C) Adjust potentiometer R67 for an indication of 895.8 mV ± 1 mV.

(D) Remove the Dc Voltage Source and connect a 249 ohm ±1% resistor (Type RN55C or equal) between pins 1 and 3 on the front-panel connector. Using the Multimeter set for operation

as an ac voltmeter on its 2 volt range, verify that the voltage across the resistor is between 434 and 461 mV.

(E) Remove the 249 ohm resistor and connect it between pins 1 and 9 on the front-panel connector. Using the Multimeter, verify that the voltage across the resistor is between 434 and 461 mV.

(F) Remove the 249 ohm resistor and connect a 200 ohm ±1% resistor (Type RN55C or equal) between pins 1 and 4 on the front-panel connector. Using the Multimeter, verify that the voltage across the resistor is between 434 and 461 mV.

(G) Remove the 200 ohm resistor and Multimeter, and replace the Dc Voltage Source. Set the OPR-CAL switch to OPR.

4.13 RANGE-TO-RANGE ADJUSTMENTS AND ACCURACY TEST

(A) Set the unit under test to the 10 mW range.

(B) Connect to the Dc Voltage Source nanovolt binding post and zero the unit under test.

(C) Using the Dc Voltage Source on the millivolt range, apply 4.31 mV to the unit under test.

(D) Set the CAL FACTOR control to 100%.

(E) Set the Multimeter for operation as a dc voltmeter on its 2 volt range and connect it between the OUTPUT binding posts.

(F) Adjust CAL screwdriver control for an indication of 1.00V ±1 mV on the Multimeter.

(G) Adjust potentiometer R35 for an indication of 10 on the "10" front-panel meter scale.

(H) Using the Dc Voltage Source, apply 1.36 mV to the unit under test.

(I) Set the unit under test to the 3 mW range.

(J) Adjust potentiometer R38 for an indication of 10 on the "10" front-panel meter scale.

(K) Verify that the Multimeter indicates 316 ±1.6 mV.

(L) Connect the Dc Voltage Source on the microvolt binding post and apply 431 uV to the unit under test.

(M) Set the unit under test to the 1 mW range.

(N) Verify that the Multimeter indicates 1000 ±5 mV.

(O) Repeat steps L thru N in accordance with the following tabulation: **

Binding Post	Dc Voltage	Range	Multimeter Indication
uV	136 uV	.3 mW	316 ±1.6 mV
uV	43.1 uV	100 uW	1000 ±5 mV
uV	13.6 uV	30 uW	316 ±1.6 mV
uV	4.31 uV	10 uW	1000 ±5 mV
uV	1.36 uV	3 uW	316 ±1.6 mV
nV	431 nV	1 uW*	1000 ±5 mV
nV	136 nV	.3 uW*	316 ±1.6 mV

*NOTE

Due to the presence of noise and drift on these two sensitive ranges, sequentially zero the unit under test and apply the dc voltages indicated several times, each time noting both the zero and full scale readings on the Multimeter. The true indication in the fourth column of the tabulation is intended to be the average algebraic difference between the two readings.

(P) Set the unit under test to the 10 mW range and apply 4.31 mV using the Dc Voltage Source.

(Q) Connect pin 5 to pin 6 on the unit under test front-panel connector.

(R) Verify that the Multimeter indicates 930 ±5 mV.

(S) Apply 1.36 mV to the unit under test using the Dc Voltage Source.

(T) Verify that the Multimeter indicates 309 ±2 mV.

(U) Remove the connection between pins 5 and 6 on the front-panel connector.

(V) Zero the unit under test and apply 4.31 mV using the Dc Voltage Source.

** Zero set as required.

(W) Set the CAL FACTOR control to 86%, and verify that the Multimeter indicates 1140 ±15 mV.

4.14 NOISE TEST

(A) Set the unit under test to the .3 uW range.

(B) Zero the unit under test.

(C) Apply 43.1 nV to the unit under test using the Dc Voltage Source.

(D) Verify that the noise as seen on the "10" scale of the front-panel meter is less than 1-1/2 small divisions peak-to-peak.

(E) Repeat steps B through D with the ac input to the unit under test adjusted to 115 VAC, 50 Hz and 115 VAC, 400 Hz.

4.15 ZERO CARRYOVER TEST

(A) Check that the unit is set to its .3 uW range.

(B) Zero the unit under test.

(C) Sequentially set the unit under test to each of its remaining ranges and verify that its front-panel meter indicates zero at all positions.

4.16 RESPONSE TIME TEST

(A) Connect the Oscilloscope between the OUTPUT binding posts.

(B) Set the Oscilloscope sensitivity and sweep rate to 200 mV/cm and 0.5 second/cm, respectively, with storage ON.

(C) Set the unit under test to the 1 uW range.

(D) Set the Dc Voltage Source to apply 431 nV to the unit under test, but do not apply it to the unit under test at this point.

(E) Zero the unit under test, and continue to depress the ZERO button.

(F) Adjust the Oscilloscope trace to be 2.5 graticule lines above the zero graticule reference line.

(G) Release the ZERO button and erase the Oscilloscope trace. At the beginning of the next trace, apply the voltage established in step D, and verify that the rise time (10 to 90%) of the waveform is less than 3.74 seconds.

(H) Remove the voltage established in step D, and verify that the fall time (10-90%) of the waveform is less than 3.74 seconds.

(I) With oscilloscope set to .2 instead of .5, repeat steps C thru G in accordance with the following tabulation:

Range	Dc Voltage	Rise Time
10 uW	4.31 uV	1.1 sec max
100 uW	43.1 uV	1.1 sec max
1 mW	431 uV	1.1 sec max
10 mW	4.31 mV	1.1 sec max

(J) Remove the Oscilloscope.

4.17 RF BLANKING TEST

(A) Set Multimeter for operation as an ohmmeter and connect it between the RF BLANKING connector at the rear of the unit under test and ground.

(B) Verify that the Multimeter indicates an open circuit.

(C) Depress the unit under test ZERO button and verify that the Multimeter indicates a short circuit. Remove the Multimeter.

4.18 CAL MODE AUTO RANGING TEST

(A) With the unit under test still set to the CAL mode, connect pin 5 to pin 6 on its front-panel connector.

(B) Using the Dc Voltage Source, apply 43.1 uV to the unit under test. Verify that the unit under test indicates full scale on all ranges.

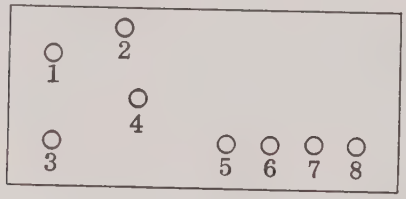
(C) Remove the connection between pins 5 and 6 on the front-panel connector, and apply 431 uV to the unit under test using the Dc Voltage Source. Verify that the unit under test indicates full scale on all ranges.

4.19 AUTO-ZERO MODULE TEST

The following test need be performed only if it is desired to check operation of an Auto-Zero Module that is disconnected from a Model 476. Be certain to proceed in the exact sequence shown.

(A) Set the Multimeter for use as an ohmeter and verify that the resistance between pins 1 and 7 is between 61K and 63K ohms. The

pin assignments can be determined from the following illustration:



(B) Set the Multimeter for use as a dc voltmeter and connect it between pins 3 (+) and 7 (-).

(C) Apply 24 VDC between pins 4 (+) and 2 (-).

(D) Apply 7.12 VDC between pins 7 (+) and 6 (-).

(E) Connect a second 7.12 VDC source between pins 8 (+) and 7 (-).

(F) Connect pin 5 to pin 7.

(G) Verify that the Multimeter indicates between -1 and +2 VDC. Note indication.

(H) De-energize the 24 VDC power supply.

(I) Remove the connection between pins 5 and 7, and connect pin 5 to pin 6.

(J) Verify that the Multimeter reading is the same as that noted in step G.

(K) Energize the 24 VDC power supply for approximately 5 seconds, and de-energize it.

(L) Verify that the Multimeter indicates between -2 and -7.12 VDC. Note indication.

(M) Remove the connection between pins 5 and 6, and connect pin 5 to pin 8.

(N) Verify that the Multimeter reading is the same as that noted in step L.

(O) Energize the 24 VDC power supply for approximately 5 seconds, and de-energize it.

(P) Verify that the Multimeter indicates between +1.2 and +7.12 VDC. Note indication.

(Q) De-energize both 7.12 volt supplies for approximately 60 seconds, and energize them.

Verify that the Multimeter reading is the same as that noted in step P.

(R) Make the following calculation:
(.00186) X (Step 6 indication) ±5%.

(S) Remove the Multimeter connection from pin 3 and connect it to pin 1.

(T) Verify that the Multimeter indication is between the limits calculated in step R.

SECTION V

PARTS LIST

5.0 GENERAL PARTS INFORMATION

Standard readily available components are used in the manufacture of GMC instruments whenever possible. Such parts can usually be obtained from a local dealer. Special or modified parts, as determined by an entry in the last column of the Table of Replaceable Parts (GMC Dwg. No.), are available from GMC.

When ordering parts from GMC, please indicate your instrument model and serial number, plus the data given in the Table of Replaceable Parts.

When using the Table of Replaceable Parts, note that each part is located to a major assembly by means of the entry in the TOTAL NO USED column. The specific locations that correspond to the codes follow:

(A) Front or rear panel

(B) RANGE switch assembly

(C) Isothermal assembly

(D) Printed circuit board assembly (large board located on top of unit)

Most components can be easily located by the reference designations which appear on the printed circuit boards or chassis. Those components which have not been so identified can be easily located using the schematic diagram appearing in Section III of this technical manual, with the following possible exceptions:

R103: Located on Power switch

C38: Located on ZERO switch

TABLE 5.1

REPLACEABLE PARTS, MODEL 476

REF DES	DESCRIPTION	TOTAL NO. USED A	B	C	D	MFRS CODE	GMC DWG NO.
A1	DIODE BRIDGE; P/N W04M				1	14936	
CR1, CR2 CR3	SEMICONDUCTOR DEVICE, DIODE; P/N 1N4148				5	01295	
CR4	NOT USED						
CR5	SAME AS CR1				5		
CR6	SEMICONDUCTOR DEVICE, DIODE; P/N 10D2				2	81483	
CR7	NOT REPLACEABLE						
CR8	SEMICONDUCTOR DEVICE, DIODE; P/N 1N4148		1			01295	
CR9	SAME AS CR6				2		
CR10-CR200	NOT USED						
CR201	DIODE, SCHOTTKY; P/N HP5082-2900				2	28480	
CR202	SAME AS CR1				5		

TABLE 5.1 (CONT'D)

REF DES	DESCRIPTION	TOTAL NO. USED A	B	C	D	MFRS CODE	GMC DWG NO.
CR203	SAME AS CR201				2		
C1	CAP, FXD, MYLAR, 0.1 uF ±10%; 100V; P/N DMF1P1-10				1	14655	
C2	CAP, FXD, TA, 1 uF ±20%, 35V; P/N 196D105X0035HA1				3	56289	
C3	CAP, FXD, TA, 0.68 uF ±10%, 6V; P/N 196D684X9035HA1				1	56289	
C4	CAP, FXD, TA, 68 uF ±20%, 10V; P/N T362C686M010AS				1	56289	
C5, C6	CAP, FXD, POLYCARBONATE, 0.1 uF ±20%, 250V; P/N C280AE/P100K				2	73445	
C7, C8	CAP, FXD, TA, 0.47 uF ±20%, 35V; P/N 196D474X0035HA1				2	56289	
C9	CAP, FXD, TA, 10 uF ±10%, 35V; P/N 150D106X9035R2				1	56289	
C10	CAP, FXD, TA, 4.7 uF ±10%, 35V; P/N 150D475X9035B2				1	56289	
C11, C12	CAP, FXD, EPOXY CTD, 1000pF ± 5% 100V; P/N 2120BN100R102J				2	72982	
C13	CAP, FXD, CER, 68 pF ±5%, 500V (TYPE CD15); P/N ED680J03				1	14655	
C14	CAP, FXD, TA, 10 uF ±10%, 35V; P/N 196D106X9035PE4				1	56289	
C15, C16	CAP, FXD, POLYCARBONATE, 1 uF, 50V; P/N ACR-50-1-10				2	31589	
C17	NOT REPLACEABLE						
C18	CAP, FXD, CER, 10 pF ±10%, 100V; P/N 8101-100-C0G0-100K				2	72982	
C19	CAP, FXD, CER, 150 pF ±10%, 100V; P/N 8101-100-W5R0-151K				2	72982	
C20	CAP, FXD, ELECTROLYTIC (AL), 500 uF, 35V; P/N TVA-1227				1	56289	
C21, C22	CAP, FXD, CER, 1000 pF ±20%, 50V; P/N 8101-050-651-102M				3	72982	
C23, C24	CAP, FXD, TA, 10 uF ±20%, 25V; P/N 196D106X0025KA1				3	56289	

TABLE 5.1 (CONT'D)

REF DES	DESCRIPTION	TOTAL NO. USED A	B	C	D	MFRS CODE	GMC DWG NO.
C25	SAME AS C19				2		
C26	CAP, FXD, TA, 47 uF ±20%, 35V; P/N 196D476X0035TE4				1	56289	
C27, C28	CAP, FXD, TA, 2.2 uF ±20%, 25V; P/N 196D225X0025HA1				2	56289	
C29	CAP, FXD, POLYCARBONATE, .033 uF ±10%, 250V; P/N C280AE/A33K				1	73445	
C30	NOT REPLACEABLE						
C31	CAP, FXD, TA, 5.6 uF ±10%, 20V; P/N 150D565X9020B2				1	56289	
C32, C33	CAP, FXD, CER, .01 uF ±20%, 50V; P/N 8121-050-651-103M				2	72982	
C34	NOT REPLACEABLE						
C35	NOT REPLACEABLE						
C36	SAME AS C21				3		
C37	SAME AS C23				3		
C38	CAP, FXD, TA, 10 uF ±10%, 35V; P/N 196D106X9035PE4	1				56289	
C39, C40	SAME AS C2				3		
C41	NOT USED						
C42, C43	CAP, FXD, CER, .01 uF ±20%, 1000V; P/N 5GA-S10	2				56289	
C44	SAME AS C18				2		
C45-C47	NOT USED						
C48	CAP, FXD, TA, 33 uF ±20%, 10V; P/N T362B336M010AS				1	31433	
DS1, DS2	DIODE, LIGHT EMITTING; P/N 5082-4684	2				28480	
F1	FUSE, 0.1A, SLO-BLOW; P/N 313.100	1				75915	
G1	CHOPPER, ELEC			1		11332	8325P1
J1	CONNECTOR, LOW-THERMAL EMF	1				11332	8343P1

TABLE 5.1 (CONT'D)

REF DES	DESCRIPTION	TOTAL NO. USED A	B	C	D	MFRS CODE	GMC DWG NO.
J2	CONNECTOR, PRINTED CIRCUIT; P/N 225-22221-101	1				02660	
J3	CONNECTOR, BNC; P/N UG-1094/U	1				02660	
J4	CONNECTOR, AC POWER, P/N EAC-301	1				82389	
K1	NOT REPLACEABLE						
K2	RELAY, DPDT; P/N R50S-EZ-YZ-24V		1			12300	
M1	METER, 4-1/2"	1				11332	7914-3
Q1	TRANSISTOR; P/N 2N4250				1	04713	
Q2	TRANSISTOR; P/N PN4393				2	12040	
Q3-Q7	TRANSISTOR; P/N 2N2222				5	04713	
Q8-Q9	TRANSISTOR; P/N 2N2907A				2	01295	
Q10	NOT REPLACEABLE						
Q11-Q200	NOT USED						
Q201	SAME AS Q2				2		
R1	RES, FXD, FILM, 100K OHMS ±1%; P/N RN55C1003F				2	91637	
R2	RES, FXD, FILM, 249K OHMS ±1%; P/N RN55C2493F				1	91637	
R3	RES, FXD, FILM, 1 MEGOHMS ±5%; P/N CC1004F				1	01121	
R4	RES, FXD, COMP, 16K OHMS ±5%; P/N RC07GF163J				1	01121	
R5	RES, FXD, COMP, 620K OHMS ±5%; P/N RC07GF624J				2	01121	
R6	RES, FXD, FILM, 475K OHMS ±5%; P/N RN55C4753F				1	91637	
R7	RES, FXD, FILM, 4.64K OHMS ±1%; P/N RN55C4641F				1	91637	
R8	RES, VAR, FILM, 200 OHMS; P/N 63P201				2	02111	
R9	RES, FXD, FILM, 249 OHMS ±1%; P/N RN55C2490F				1	91637	
R10	SAME AS R5				2		

TABLE 5.1 (CONT'D)

REF DES	DESCRIPTION	TOTAL NO. USED A	B	C	D	MFRS CODE	GMC DWG NO.
R11	RES, FXD, FILM, 634K OHMS ±1%; 1/2W; P/N RN60D6343F				1	91637	
R12, R13	RES, FXD, FILM, 10K OHMS ±1%; P/N RN55C1002F				7	91637	
R14	RES, FXD, COMP, 4.7K OHMS ±5%; P/N RC07GF472J				6	01121	
R15, R16	RES, FXD, COMP, 47K OHMS ±5%; P/N RC07GF473J				3	01121	
R17	RES, FXD, COMP, 100K OHMS ±5%; P/N RC07GF104J				6	01121	
R18	SAME AS R15				3		
R19	NOT USED						
R20	RES, FXD, COMP, 51 OHMS ±5%; P/N RC07GF510J				2	01121	
R21	RES, FXD, FILM, 1K OHMS ±1%; P/N RN55C1001F				2	91637	
R22	RES, FXD, FILM, 499 OHMS ±1%; P/N RN55C4990F				1	91637	
R23	RES, FXD, FILM, 1.11K OHMS ±0.1%; P/N RN55C1111B				1	91637	
R24	RES, FXD, FILM, 10K OHMS ±0.1%; P/N RN55C1002B				1	91637	
R25	SAME AS R20				2		
R26	RES, FXD, FILM, 2317 OHMS ±0.1%; P/N MFF-1/8-T2-2317		1			91637	
R27	RES, FXD, FILM, 20.94K OHMS ±0.1%; P/N MFF-1/8-T2-20942		1			91637	
R28	RES, FXD, FILM, 209.4K OHMS ±0.1%; P/N MFF-1/2-T2-209400		1			91637	
R29	RES, FXD, FILM, 2.094 MEGOHMS ± 0.1%; P/N 9852-2B		1			65092	
R30	RES, VAR, FILM (CAL)	1				11332	8331P3
R31	RES, FXD, FILM 4.12K OHMS ±1%; P/N RN55C4121F				1	91637	
R32	RES, VAR, FILM (CAL FACTOR)	1				11332	8330P1

TABLE 5.1 (CONT'D)

REF DES	DESCRIPTION	TOTAL NO. USED A	B	C	D	MFRS CODE	GMC DWG NO.
R33	RES, FXD, FILM, 7.15K OHMS ±1%; P/N RN55C7151F				1	91637	
R34	NOT USED						
R35	SAME AS R8				2		
R36	RES, FXD, FILM, 3.48K OHMS ±1%; P/N RN55C3481F				1	91637	
R37	RES, FXD, FILM, 909 OHMS ±1%; P/N RN55C9090F				1	91637	
R38	RES, VAR, FILM, 100 OHMS; P/N 63P101				1	02111	
R39	RES, FXD, FILM, 287 OHMS ±1%; P/N RN55C2870F				1	91637	
R40	RES, FXD, COMP, 1K OHMS ±5%; P/N RC07GF102J		1			01121	
R41	NOT REPLACEABLE						
R42	RES, FXD, COMP, 300 OHMS ±5%; P/N RC07GF301J		1			01121	
R43	RES, FXD, COMP, 100 OHMS ±5%; P/N RC07GF101J		1			01121	
R44	NOT REPLACEABLE						
R45, R46	RES, FXD, COMP, 15K OHMS ±5%; P/N RC07GF153J				3	01121	
R47	RES, FXD, FILM, 49.9 OHMS ±1%; P/N RN55C49R9FM			1		91637	
R48	NOT REPLACEABLE						
R49	NOT REPLACEABLE						
R50	NOT REPLACEABLE						
R51	NOT REPLACEABLE						
R52	NOT REPLACEABLE						
R53	SAME AS R17				6		
R54	RES, FXD, COMP, 18 K OHMS ±5%; P/N RC07GF183J				1	01121	
R55	RES, FXD, COMP, 39K OHMS ±5%; P/N RC07GF393J				1	01121	

TABLE 5.1 (CONT'D)

REF DES	DESCRIPTION	TOTAL NO. USED A	B	C	D	MFRS CODE	GMC DWG NO.
R56, R57	RES, FXD, FILM, 15.8K OHMS ±1%; P/N RN55C1582F				2	01121	
R58	RES, FXD, FILM, 49.9K OHMS ±1%; P/N RN55C4992F				1	91637	
R59	RES, FXD, FILM, 24.9K OHMS ±5%; P/N RN55C2492F				1	91637	
R60	SAME AS R1				2		
R61, R62, R63	RES, FXD, FILM, 20K OHMS ±1%; P/N RN55C2002F				3	91637	
R64	SAME AS R12				7		
R65	RES, FXD, FILM, 200 OHMS ±1%; P/N RN55C2000FM			1		91637	
R66	RES, FXD, FILM, 348K OHMS ±1%; P/N RN60D3483F				1	91637	
R67	RES, VAR, FILM, 100K OHMS ±10%; P/N 43-P-104				1	02111	
R68	SAME AS R21				2		
R69	SAME AS R12				7		
R70	RES, FXD, FILM, 4.99K OHMS ±1%; P/N RN55C4991F				2	91637	
R71	SAME AS R12				7		
R72	SAME AS R70				2		
R73	RES, FXD, COMP, 10 OHMS ±5%, 2W; P/N RC42GF100J				1	01121	
R74	RES, FXD, FILM, 71.5K OHMS ±1%; P/N RN55C7152F				1	91637	
R75	RES, FXD, FILM, 17.8K OHMS ±1%; P/N RN55C1782F				1	91637	
R76	SAME AS R45				3		
R77	SAME AS R14				6		
R78	RES, FXD, COMP, 100 OHMS ±5%; P/N RC07GF101J				2	01121	
R79, R80	RES, VAR, FILM, 10K OHMS; P/N 63P103				2	02111	
R81	RES, FXD, WIREWOUND			1		11332	8326P1

TABLE 5.1 (CONT'D)

REF DES	DESCRIPTION	TOTAL NO. USED A	B	C	D	MFRS CODE	GMC DWG NO.
R82, R83	SAME AS R17				6		
R84	RES, FXD, COMP, 1.3K OHMS ±5%; P/N RC07GF132J				1	01121	
R85	RES, FXD, COMP, 1.5K OHMS ±5%; P/N RC07GF152J				1	01121	
R86	SAME AS R78				2		
R87	SAME AS R17				6		
R88	RES, VAR, FILM, 1K OHMS; P/N 63P102				1	02111	
R89	RES, FXD, FILM, SELECT VALUE AT TEST; STYLE RN55C				1	91637	
R90	RES, FXD, FILM, SELECT VALUE AT TEST; STYLE RN55C				1	91637	
R91, R92 R93	SAME AS R14				6		
R94	RES, FXD, COMP, 27 OHMS ±5%; P/N RC07GF270J				1	01121	
R95	SAME AS R14				6		
R96	RES, VAR, CER, 10K OHMS ±10%; P/N 64Y103				1	02111	
R97	NOT USED						
R98	NOT USED						
R99	NOT USED						
R100, R101	SAME AS R12				7		
R102	RES, FXD, COMP, 68K OHMS ±5%; P/N RC07GF683J				1	01121	
R103	RES, FXD, FILM, 28.7K OHMS ±1%; P/N RN55C2872F	1				91637	
R104	RES, FXD, COMP, 3.3K OHMS ±5%; P/N RC07GF332J				1	01121	
R105	RES, FXD, COMP, 100 MEGOHMS ±5%; P/N CB07GF107J				1	01121	
R106	RES, FXD, COMP, 200K OHMS ± 5%; P/N RC07GF204J				1	01121	
R107, R108	NOT USED						

TABLE 5.1 (CONT'D)

REF DES	DESCRIPTION	TOTAL NO. USED A	B	C	D	MFRS CODE	GMC DWG NO.
R109	RES, FXD, COMP, 180 OHMS ±5%, 1W; P/N RC32GF181J				1	01121	
R110	RES, FXD, COMP, 1K OHMS ±5%; P/N RC07GF102J				1	01121	
R111-R200	NOT USED						
R201	RES, FXD, COMP, 10K OHMS ±5%; P/N RC07GF103J				1	01121	
R202	RES, FXD, COMP, 82K OHMS ± 5%; P/N RC07GF823J				1	01121	
R203	RES, FXD, COMP, 180K OHMS ±5%; P/N RC07GF184J				1	01121	
R204	RES, FXD, COMP, 430K OHMS ±5%; P/N RC07GF434J				1	01121	
R205	SAME AS R17				6		
R206	RES, FXD, COMP, 220K OHMS ±5%; P/N RC07GF224J				1	01121	
R207	RES, FXD, COMP, 27K OHMS ±5%; P/N RC07GF273J				1	01121	
S1	SWITCH, RANGE		1			11332	8323P1
S2	SWITCH, OPR-CAL	1				11332	8341P1
S3	SWITCH, ZERO	1				11332	8328P1
S4	SWITCH SLIDE, DPDT W/.013 SLOTTED KNOB; P/N GF-326 MOD (115-230V)	1				79727	
S5	SWITCH, TOGGLE (POWER)	1				11332	8329P1
S6	SWITCH, SLIDE; P/N 23-021-304				1	10389	
T1	TRANSFORMER, CHOPPER			1		11332	8324P1
T2	TRANSFORMER	1				11332	8332P1
U1	I.C. AMPLIFIER; P/N LM1458N				2	12040	
U2, U3	I.C. AMPLIFIER; P/N LM747CN				3	12040	
U4	SAME AS U1				2		
U5, U6	I.C. AMPLIFIER; P/N LM301AN				2	12040	
U7	SAME AS U2				3		

TABLE 5.1 (CONT'D)

REF DES	DESCRIPTION	TOTAL NO. USED A	B	C	D	MFRS CODE	GMC DWG NO.
U8	I.C. REGULATOR; P/N RC4194D				1	07933	
U9	I.C. AMPLIFIER; P/N LM741CN				1	12040	
U10	I.C. REGULATOR; P/N LM340LAH-12				1	12040	
U11-U200	NOT USED						
U201	OPTO-ISOLATOR; P/N IL-74				1	50579	
VR1	SEMICONDUCTOR DEVICE, DIODE; P/N 1N825A				1	01295	
W1	AC LINE CORD AND PLUG SET, 3 COND; P/N P-2392	1				82389	
XF1	FUSEHOLDER; P/N 342004	1				75915	
	AUTO ZERO MODULE			1		11332	8334G1

TABLE 5.2

MANUFACTURERS' CODES

CODE	MANUFACTURER	ADDRESS
01121	Allen Bradley Co.	Milwaukee, Wisc.
01295	Texas Instruments, Inc.	Dallas, Texas
02111	Spectrol Electronics Corp.	City of Industry, CA
02660	Amphenol Connector Div.	Broadview, Ill.
02799	Arco Capacitors, Inc.	Los Angeles, CA
04713	Motorola Semiconductor Products, Inc.	Phoenix, AZ
07263	Fairchild Semiconductor Products, Inc.	Mountain View, CA
07933	Raytheon Co.	Mountain View, CA
10389	Chicago Switch, Inc.	Chicago, Ill.
11332	General Microwave Corp.	Farmingdale, N.Y.
12040	National Semiconductor Corp.	Danbury, Conn.
12300	Potter and Brumfield Div. AMF Canada	Guelph, Ontario
14655	Cornell-Dubilier Electronics	Newark, N.J.
14936	General Instrument Corp.	Hicksville, N.Y.
28480	Hewlett-Packard Co.	Palo Alto, CA
31433	Kemet Div. of Union Carbide Corp.	Greenville, S.C.
31589	APC Mfg. Co.	Massapequa, N.Y.
50579	Litronix	Cupertino, CA
56289	Sprague Electric Co.	N. Adams, MA
65092	Weston Instruments, Inc.	Newark, N.J.
72982	Erie Technological Products, Inc.	Erie, PA
73445	Amperex Electronics Corp.	Hicksville, N.Y.
75915	Littelfuse, Inc.	Des Plaines, Ill.
78277	Sigma Instruments	So. Braintree, MA
79727	Continental-Wirt Electronics	Warminster, PA
81483	International Rectifier Corp.	Los Angeles, CA
82389	Switchcraft, Inc.	Chicago, Ill.
91637	Dale Electronics, Inc.	Columbus, Nebr.

EQUIPMENT WARRANTY

General Microwave Corporation warranties all parts of equipment of its manufacture to be free from defects caused by faulty material or poor workmanship. This warranty excludes electronic tubes, batteries, natural rubber and material normally consumed in operation unless such excepted items fail as a result of improper application by General Microwave.

Liability under this warranty is limited to the obligation to repair, or, at General Microwave's sole option, to replace without charge, FOB General Microwave's Plant, any part found to be defective under normal use and service within the time periods shown below, provided:

(1) General Microwave Corporation is promptly notified within the warranty period in writing upon discovery of such defects;

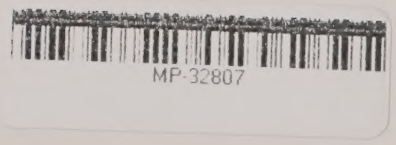
(2) The original parts or equipment are returned to General Microwave Corporation, transportation charges prepaid;

(3) General Microwave Corporation's examination shall disclose to its satisfaction that such defects have not been caused by abuse after delivery; and

(4) Warranties shall not apply to items which have been repaired or altered by others than General Microwave Corporation or its authorized agency.

The period of warranty is one year after delivery of the instrument to the original purchaser.

The warranty period shall not include any period of time the unit or part fails to perform satisfactorily due to such defect, and any unit, part or component repaired or replaced by General Microwave pursuant to this warranty shall itself be guaranteed as specified above.


MP-32807